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ABSTRACT

This instructional package, one in a series of individualized instructional units on automobile air conditioning, consists of a student guide and an instructor guide dealing with the principles of refrigeration. Covered in the module are defining the term heat, defining the term British Thermal Unit (BTU), defining the term latent heat, listing the three methods of transferring heat, describing the effect of pressure on vaporization and evaporation of the refrigerant, and describing what happens in the air conditioning system as the refrigerant makes a complete circuit. The student guide contains an introduction, a list of procedures for completing the unit, and an information sheet. Included in the instructor guide are an introduction, performance objectives, a list of references, suggested activities, a student posttest, answers to the posttest, and instructional script. (MN)

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INSTRUCTOR'S GUIDE

PROGRAM: Automotive Mechanics **UNIT TITLE:** Air Conditioning

MODULE TITLE: Principles of Refrigeration **MODULE NO.** AM-83-300

INTRODUCTION:

Understanding the principles of refrigeration is a must if students are going to service and repair automotive air conditioners. Once students know how system components operate, finding and repairing a problem in the system is much easier to accomplish.

PERFORMANCE OBJECTIVES:

The student should be able to:

1. Define heat.
2. Define B.T.U.
3. Define latent heat.
4. List the three methods of transferring heat.
5. Describe the effects of pressure on vaporization and evaporation of the refrigerant.
6. Describe what happens in the air conditioning system as the refrigerant makes a complete circuit.

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Learning Groups Designed For:

☒ Adult
☐ Special Needs
☒ Secondary
☒ Post Secondary

Written By:

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TEACHING/LEARNING RESOURCES:

☒	Student Packet	☐	Videocassette
☒	Instructor's Guide, Key, and Script	☐	Film Loop
☒	35 mm Slide Presentation	☒	Audiocassette
☐	Filmstrip		

REFERENCES:

Stockel, Martin W. Auto Mechanics Fundamentals, The Goodheart-Willcox Co., Inc., 1978.

Crouse, William H., Anglin, Donald L., Automotive Air Conditioning, McGraw-Hill Book Company, 1977.

INSTRUCTIONAL METHODS SUGGESTED:

This packet is designed for individualized instructional programs and scheduling for open-entry/open-exit programs. However, these materials can be used to supplement traditional instruction methods. Tests can be used for pretesting for advanced placement of students who are already competent in this area. Demonstrations by the instructor are recommended to enhance student learning.

KEY

AM-83-300

STUDENT EVALUATION

1. The automotive air conditioner not only cools the air entering the car, but also CLEANS and DEHUMIDIFIES it.
2. Heat can be defined as a form of ENERGY.
3. Three ways heat can be transferred are CONDUCTION, CONVECTION, and RADIATION.
4. Define the British Thermal Unit. AMOUNT OF HEAT TO RAISE ONE POUND OF WATER ONE DEGREE FAHRENHEIT
5. The temperature of both evaporation and condensation are affected by PRESSURE.
6. Heat that is absorbed with no increase in temperature is LATENT HEAT.
7. Two purposes of the receiver-drier are STORE LIQUID FREON and REMOVE MOISTURE.
8. Besides circulating the refrigerant, the compressor also INCREASES PRESSURE and INCREASES TEMPERATURE of the refrigerant.
9. Refrigerant 12 boils at 21.7° F.
10. Starting at the receiver-drier, explain what happens in an operating air conditioning system. LIQUID REFRIGERANT COLLECTS IN THE RECEIVER-DRIER WHERE EXCESS MOISTURE IS REMOVED. FROM THERE IT GOES TO THE EXPANSION VALVE WHERE IT IS METERED TO THE EVAPORATOR AND THE PRESSURE IS LOWERED. THE BOILING LIQUID REFRIGERANT IN THE EVAPORATOR TURNS TO A WARM VAPOR UPON ABSORBING HEAT FROM THE AIR PASSING OVER THE EVAPORATOR COIL. THE WARM VAPOR LEAVING THE EVAPORATOR ENTERS THE COMPRESSOR WHERE THE PRESSURE AND TEMPERATURE IS INCREASED. THE HOT, HIGH PRESSURE VAPOR ENTERS THE CONDENSER WHERE IT CONDENSES BACK TO A LIQUID AND RE-ENTERS THE RECEIVER-DRIER.

AM-83-300 PRINCIPLES OF REFRIGERATION - Script

1. This is a presentation of The Media Center, State Fair Community College, Sedalia, Missouri.
2. AM-83-300, Principles of Refrigeration.
3. Automotive air conditioning adds to passenger comfort by cooling, cleaning and removing the moisture from the incoming air. Application of the principles of refrigeration makes all this possible.
4. For the student to service and repair the automotive air conditioner, it is important to first have an understanding of the refrigeration process.
5. After completing this module, you should be able to:
 1. Define heat.
 2. Define B.T.U.
 3. Define latent heat.
 4. List the three methods of transferring heat.
 5. Describe the effects of pressure on vaporization and evaporation of the refrigerant.
 6. Describe what happens in the air conditioning system as the refrigerant makes a complete circuit.
11. In order to have an understanding of refrigeration, you must first have an understanding of the principles of physical laws that make the refrigeration process possible.
12. We all know what happens when we step on a scale. The scale shows how much we weigh, whether we like it or not.
13. This is a physical law. Due to the mass of your body you exert a force that is registered on the scale. Gravity is this law; you can change the mass of your body by eating more or less, but you can't change gravity.
14. To live, we must breath air.
15. But, did you realize that air is affected by gravity just as you. In fact, one square inch of air extending to the end of the atmosphere is affected by the gravitational pull to such an extent that it weighs about 14.7 pounds at sea level.
16. Since the air is all around us, this weight or pressure is all around us exerting a pressure of 14.7 pounds on every square inch equally in all directions.

17. If you place a pan of water on a stove at sea level, it would boil at 212 degrees.
18. On a high mountain you would have less air above you which results in less air pressure. That pan of water that boiled at 212 degrees at sea level would boil at a much lower temperature on the mountain.
19. As you can see, increasing or decreasing the pressure will have a likewise effect on the temperature at which a substance boils.
20. Heat, a form of energy, causes the water to boil and the pressure on the water determines how much heat is required to cause boiling.
21. Heat can be transferred from one object to another in three ways:
 1. Conduction
 2. Convection
 3. Radiation
22. The pan of water on the stove is heated by conduction. The heat is transferred directly to the water.
23. Your home is heated by convection. The air is warmed by the stove and the air then transfers its heat to the objects in the room.
24. The sun transfers its heat by radiation or infrared rays. These rays, while containing no heat, have the ability to cause molecules of other substances to increase their speed imparting heat to the object.
25. As you can see, whether by conduction, convection, or radiation, when two objects are placed reasonably close, the hotter object will give up its heat to the cooler object. Eventually both will be the same temperature.
26. The British Thermal Unit or BTU is a means of measuring this transfer of heat.
27. When the temperature of one pound of water is raised one degree, one BTU of heat has been transferred to the water.
28. When a substance such as water is heated sufficiently, it will boil and turn to vapor. Remember, for water that temperature is 212 degrees at sea level.
29. The boiling water is 212 degrees and the vapor or steam is 212 degrees!

30. No matter how much more heat is applied to the water, it will not become hotter than 212 degrees.
31. The heat added, without increase in temperature, is referred to as latent or hidden heat.
32. When latent heat hidden in water vapor contacts cooler air, it will condense, transferring water vapors back to liquid.
33. This physical law known as latent heat of vaporization is the principle of refrigeration, the transfer of heat involved in changing a liquid to vapor and vapor back to liquid.
34. This is a review of the material covered so far: (pause) Raising the pressure on a substance raises the boiling point. Lowering the pressure lowers the boiling point.
35. Heat can be transferred from one substance to another by conduction, convection, and radiation.
36. The amount of heat transferred can be measured by a unit of measurement called a B.T.U.
37. Heat can be applied to a substance with no increase in temperature and is referred to as latent heat.
38. A vapor will give up latent heat and condense back to a liquid. This is referred to as latent heat of vaporization.
39. Now let's relate this information to the refrigeration process, specifically as it applies to automotive air conditioning.
40. Refrigerant 12 is the substance most commonly used as a refrigerant in the automotive air conditioner.
41. Refrigerant 12 has a boiling point of minus 21.7 degrees at sea level, has no odor, and can circulate through the system endlessly without loss of efficiency. These properties make it an ideal refrigerant.
42. Let's go through a basic air conditioning system by tracing the flow of refrigerant through the various components.
43. The receiver drier collects the liquid refrigerant as it leaves the condenser. It also strains and removes any moisture that may be present in the refrigerant.
44. The liquid refrigerant, under high pressure, leaves the receiver drier and enters the expansion valve.

45. The expansion valve does two things, it meters the liquid refrigerant and lowers the pressure. This metered, low pressure refrigerant now enters (pause)
46. the evaporator. The evaporator consists of a long tube running back and forth through a series of fins. Air from a blower fan is forced past the tubes and fins and into the passenger compartment of the car.
47. The warm air passing over the evaporator coils causes the low pressure refrigerant in the coils to boil. This boiling refrigerant removes a great amount of heat from the air passing over the evaporator coils.
48. Excess moisture in the warm air contacting the cold evaporator condenses and is drained off. The dry cold air is then blown into the passenger compartment of the car.
49. To prevent the moisture from freezing on the evaporator coils and obstructing the air flow, several different methods may be used to control evaporator temperature. The thermostatic switch is one type of control.
50. The thermostatis switch senses the evaporator temperature and stops the compressor by shutting off the compressor clutch. This stops the flow of refrigerant through the coils. When the coils warm enough to prevent freezing, the switch activates the clutch again repeating the cycle.
51. There is a definite relationship between the pressure on the refrigerant 12 and the temperature of the evaporator. Raising the evaporator pressure raises the boiling point of the refrigerant and its cooling effect.
52. The P.O.A. suction throttling valve is another method of controlling evaporator temperature to prevent its freezing. Located on the outlet or suction side of the evaporator it regulates the evaporator pressure, maintaining about 30 PSI to prevent the evaporator temperature from going below 32 degrees Fahrenheit.
53. The compressor, run by a belt from the engine serves three purposes. It pumps or circulates the refrigerant through the system. It raises the pressure on the refrigerant vapor and raises the refrigerant vapor temperature.
54. The refrigerant leaving the evaporator is a vapor. Like the latent heat in the boiling water vapor, the refrigerant vapor contains large amounts of latent heat. By compressing this vapor, more heat is added to it so it is now much warmer than the outside air.

55. The refrigerant vapor is now forced into the condenser. The condenser, similar in construction to the evaporator, is normally placed in front of the car radiator where it is exposed to large quantities of cooling air.
56. The vapor in the condenser containing both the latent heat of vaporization and the heat of compression, gives up its heat to the surrounding air like the clouds in the sky condensing in the cool air forming rain drops. The refrigerant vapor cools enough to condense back to liquid by the time it leaves the condenser.
57. This liquid refrigerant is under high pressure of about 150 to 250 PSI; it's boiling point raised enough to remain a liquid, enters the receiver drier and the cycle starts all over again.
58. This is a summary of the material covered in this module.
59. Heat is a form of energy which can be transferred from one object to another by conduction, convection or radiation. Conduction heat is energy which can be transferred from one object in contact with another. Convection heat is heat energy in the air which in turn warms objects. Radiation heat is heat energy in the form of waves or particles which, when encountering an object, causes molecules to increase speed and impart heat.
60. The British Thermal Unit, B.T.U., is a standard means for measuring the transfer of heat. When the temperature of one pound of water is raised one degree, one B.T.U. of heat has been transferred to the water.
61. Latent heat describes the principle by which refrigeration works. Latent heat is heat given off or absorbed by vaporization without a change in temperature.
62. Liquid refrigerant in the evaporator of an air conditioning system will vaporize and boil when warm air comes in contact with the coils containing the refrigerant. As the refrigerant vapor leaves the evaporator, it is forced into the condenser where the refrigerant vapor cools into liquid for reuse in the system.
63. This is the end of module AM-83-300, Principles of Refrigeration. If you have questions, review the material or see your instructor.
64. (Credits)
65. (Disclaimer)
66. (Rewind)

STUDENT EVALUATION

1. The automotive air conditioner not only cools the air entering the car, but also _____ and _____ it.
2. Heat can be defined as a form of _____.
3. Three ways heat can be transferred are _____, _____, and _____.
4. Define the British Thermal Unit. _____

5. The temperature of both evaporation and condensation are affected by _____.
6. Heat that is absorbed with no increase in temperature is _____
_____.
7. Two purposes of the receiver-drier are _____
and _____.
8. Besides circulating the refrigerant, the compressor also _____
_____ and _____
of the refrigerant.
9. Refrigerant 12 boils at _____.
10. Starting at the receiver-drier, explain what happens in an operating air conditioning system. _____

STUDENT GUIDE

PROGRAM: Automotive Mechanics **UNIT TITLE:** Air Conditioning
MODULE TITLE: Principles of Refrigeration **MODULE NO.** AM-83-300

PERFORMANCE OBJECTIVES:

The student should be able to:

1. Define heat.
2. Define B.T.U.
3. Define latent heat.
4. List the three methods of transferring heat.
5. Describe the effects of pressure on vaporization and evaporation of the refrigerant.
6. Describe what happens in the air conditioning system as the refrigerant makes a complete circuit.



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INTRODUCTION

Understanding the principles of refrigeration is a must if you are going to service and repair automotive air conditioners. If you know first what a component of the system is supposed to do, finding and repairing a problem in the system is made that much easier. Think about it; if you don't know what a component of the system is supposed to do, how will you ever know if it is not working right.

PROCEDURES

1. Read the objectives and introduction to this module.
2. If you feel you can pass a test over the objectives with 90 percent or better accuracy, ask your instructor for the pretest.
3. If you do not take the pretest or do not meet the minimum requirements on the pretest, continue with the next procedure.
4. Study the information sheets which are part of this learning packet.
5. Observe and listen to slide/tape presentation AM-83-300, Principles of Refrigeration.
6. For additional information, refer to the following resources:
 - a. Stockel, Martin W., Auto Mechanics Fundamentals, The Goodheart-Willcox Co., Inc., 1978.
 - b. Crouse, William H., Anglin, Donald L., Automotive Air Conditioning, McGraw-Hill Book Co., 1977.
7. Review the objectives to be certain you understand what you are expected to have learned. Performance of the objectives will be evaluated on the posttest.
8. Ask your instructor for the test over this module. You are required to achieve at least 90 percent accuracy.

INFORMATION SHEET

Anyone who has gotten into a car on a very hot day and turned on the air conditioner appreciates the job it does. The air conditioner, besides cooling the air, also cleans the air of dust and pollen and dehumidifies it so the air entering the passenger compartment is very comfortable.

The automotive air conditioner makes use of the principle of refrigeration. Normally, when we think of refrigeration, the word "cold" comes to mind. Actually though there is no such thing as "cold." When referring to something as being cold, we are really saying it is not as hot as something else. Heat is a form of energy that can increase, decrease, or remain the same. Heat can be transferred from one object to another by conduction, the actual contact of two objects; by convection when the air around the objects is heated which in turn transfers the heat to the other object; and by radiation, like the sun transfers its heat without the presence of air or any physical contact. Since heat is a form of energy that can be transferred, the refrigeration process is made possible. The automotive air conditioner makes use of the refrigeration process which is a method of removing or transferring the heat from inside the car to the outside. With less heat in the air inside the car, you of course feel cooler and more comfortable.

The amount of heat that is transferred can be measured. The British Thermal Unit (B.T.U.) is a measurement of the transference of heat. By definition, when 1 pound of water is heated 1 degree Fahrenheit, 1 B.T.U. has been transferred to the water. When 212 B.T.U.'s have been transferred to the water (atmospheric pressure at sea level), the water will boil. Any heat added at this point will continue to be absorbed by the water but it and the vapor rising off of it will not get any hotter than 212 degrees Fahrenheit. This hidden heat that is absorbed with no increase in temperature is referred to as latent heat. This latent heat in the water vapor when contacting the cooler surrounding air gives up its heat and condenses back to a liquid. This physical law is known as

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latent heat of vaporization. Pressure has an effect on the amount of B.T.U.'s absorbed before a liquid boils. At sea level, the weight of the air above exerts a force or pressure of 14.7 pounds per square inch. At this pressure, water will boil at 212 degrees Fahrenheit. For each 3 pounds pressure added to the water, the boiling point will be raised one degree. Lowering the pressure will have the opposite effect and lower the temperature at which a liquid boils.

The principle of refrigeration actually is rather simple once you have a basic understanding of the principles of physical laws outlined previously.

The automotive air conditioner uses a liquid with a very low boiling point (-21.7°F) referred to as refrigerant 12 or the trade name Freon 12. This liquid is the medium that is used to carry the heat from the inside of the car to the outside where it is given up to the cooler outside air. The refrigeration process starts at the receiver drier, a container holding a quantity of liquid refrigerant under half pressure (150 to 250 PSI). This high pressure raises the boiling point of the refrigerant enough so that even though the refrigerant normally boils at -21.7°F , it will not boil and will remain a liquid. From the receiver drier, the refrigerant enters the expansion valve which meters it to the evaporator and lowers the pressure on the refrigerant enough that it starts to boil. The evaporator, a long tube running back and forth through a series of fins, starts to turn cold. The boiling refrigerant uses large quantities of heat and gets this heat from the tubes and fins of the evaporator. Air is then blown over the evaporator where it is cooled and then blown into the car. To prevent the evaporator from getting too cold and freezing the moisture collecting on it, a thermostatic switch is sometimes used to stop the flow of refrigerant by turning off the compressor clutch. Another method is a suction throttling valve which keeps the evaporator pressure high enough to control the boiling of the refrigerant which keeps

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the evaporator temperature within exceptable limits. By the time the refrigerant leaves the evaporator, it is a warm vapor containing large quantities of latent heat. This warm vapor then enters the compressor, a piston type pump which compresses the vapor and raises its temperature to the heat of compression. This hot high pressure vapor enters the condenser, a unit located in front of the car radiator similar in construction to the evaporator. The hot vapor as it goes through the condenser gives up its latent heat of vaporization and heat of compression to the cooler outside air so that when it leaves the condenser, it has condensed back to a liquid. This liquid then enters the receiver drier and the cycle starts all over again.